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Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

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A scanning display

This invention relates to a display device, comprising at least a first sub-pixel comprising a first light emitting organic electroluminescent layer, such as a polymer layer or a small compound molecule layer, being sandwiched between a first front electrode (anode) and a first back electrode (cathode).

Organic electroluminescent displays and devices are fairly recently discovered technologies, that are based on the realization that certain organic materials, such as for example certain polymers, may be used as a semiconductor in a light emitting diode. These devices are very interesting, due to the fact that the use of organic materials, such as polymer materials make these devices light, flexible and comparatively inexpensive to produce.

Recently, it has also been discovered that such light emitting devices may be used as a tool to measure incident light. Such a device has for example been described in the patent document US-5 504 323. This document describes a light emitting diode, which has dual functions, and thereby may be used in display technology for both input and output. When the organic polymer layer of the diode is positively biased, the diode functions as a light emitter and when the layer is negatively biased it functions as a photodiode. The negative bias preferably has a negative voltage being in the interval 2.5 to 15 V. It is also described that, since the photosensitivity of the layer increases with the reversed voltage, it is preferred to have a quite large negative bias over the organic polymer layer in the photodiode mode.

However, the dual function diode, as described above, has a number of drawbacks. To start with, the device as described in US-5 504 323 shows a non-symmetric leakage current behavior around 0 V, and the leakage currents are therefore found to be unstable. Moreover, the application of a high negative voltage leads to an increase of the failure probability of the device and the dark current is highly unstable as it is directly related to defects/ short circuits through the organic electroluminescent layer. This leads to a poor signal to noise ratio for photocurrent detection under reverse operation. Most importantly,

however, is that the devices according to the prior art are quite power consuming, due to the large driving voltages.

Moreover, a problem with such prior art displays is that it is hard to find a suitable light emitting and sensing material, which is optimal for emitting as well as sensing for a specific wavelength or wavelength interval. Such functionality is desired when generating devices such as scanners or interactive displays, in which light emitted from the display is reflected and is to be detected by the same display. An alternative device combining light emitting and light sensing abilities is therefore desired.

This and other objects are achieved by a display device as described by way of introduction, further comprising a second sub-pixel, wherein said first sub-pixel is arranged to emit light of a first wavelength and said second sub-pixel is arranged to emit light at a second wavelength, wherein said first front and back electrodes in a first state are arranged to apply an emission driving signal over said first electroluminescent layer, for generating an emission state in which light of said first wavelength is emitted, and in a second state are arranged to apply a sensing driving signal over said first electroluminescent layer, for generating a sensing state, in which light of said second wavelength, incident on said first sub-pixel may be detected. Preferably, said first electrodes (2a, 3a) are held at essentially equal potential, i.e. said sensing driving signal being a voltage having a value of essentially 0 Volts. That is, said second driving circuit is such that the power of said second driving signal has a zero value for accurately detecting an electric current generated in said organic electroluminescent layer when said organic electroluminescent layer is hit by external light. Thereby, a display device is achieved in which different sub-pixels, for different colors are assigned different functions. As an example, an RGB device may be achieved, which uses reflected light originally emitted by high-energy sub-pixels (e.g. blue) while it senses with the low energy sub-pixels (e.g. red, green). Moreover, a display is achieved which may be switched between a light emitting display mode and scanning, sensing mode. Further examples will be given below. Furthermore, since the sensing is done at a voltage of 0 Volts, the power consumption is minimized, making the display useful for mobile applications. Moreover, the above eradicates the influence of leakage currents, being a problem in prior art devices. Furthermore, an aspect of the invention is that it may be implemented in a "regular" RGB color display. In such a display, the wavelength difference between the colors is typically 100 nm (blue ~440, green ~540 nm, red ~640 nm). The invention does not put any

further limits to a choice of red, green and blue compared to the limits already put by the three colors. As described above, light emitted from said second sub-pixel, having said second wavelength, is suitably arranged to be reflected and detected by said first sub-pixel during said light sensing state, whereby a scanning device or an interactive display device may be achieved. Moreover, light emitted from said first sub-pixel suitably has a lower energy content than light emitted from said second sub-pixel.

According to a preferred embodiment of this invention the device further comprises a plurality of pixels, each comprising a first and second sub-pixel, whereby light emitted from a chosen sub-pixel is arranged to be reflected by an external reflection device, being arranged in proximity with said display device and sensed by at least one first sub-pixel within said area. Such a device may be used as an interactive display, wherein an external reflection device, such as a mirror pen, may be placed close to the display surface, in order to reflect light within a certain, limited area. The reflected light is thereafter sensed by the sensing sub-pixel(s) in question, whereby the position of the mirror pen on the display may be detected, by detecting what sub-pixels sense the reflected light. Preferably, said display comprises a plurality of pixels, and whereby light emitted from a second sub-pixel is arranged to be detected by a plurality of neighboring pixels, each having a corresponding first sub-pixel. Thereby, the spatial resolution of the scanning display device may be improved.

Preferably, said first front and back electrodes (the anode and cathode) each exhibits a work function and the difference between said work functions in larger than 1 eV, preferably within the interval 2-3.5 eV. By having a comparably large difference between said work functions, it is possible to achieve a good sensing in the sensing state as well as an optimal emission in the emission state of the display. Moreover, said emission driving signal during the first emission state and said sensing driving signal during the second sensing state, are preferably constituted by pulsed driving signals, the duration of the pulses being within the interval 0-20 ms, thereby making it possible to integrate the device in a "regular" display device, without a human eye noticing the difference. According to a preferred embodiment of this invention said sensing driving signal, in said second state, is a pulsed driving signal comprising high intensity pulses, in order to amplify the sensing driving signal. This pulsed scanning may greatly enhance the scanning, compared with continuous scanning. It may be shown that by scanning in a pulsed mode with high intensity pulses, the sensing signal may improve by two orders of magnitude or more. Moreover, the pulsed driving prevents excessive heating of the materials, which could deteriorate or even destroy the device.

The invention will hereinafter be described in closer detail with reference to the accompanying drawings.

Fig 1a shows a schematic drawing of a dual function display device, having a first and a second sub-pixel, the display being in a light emitting state.

Fig 1b shows a schematic drawing of the dual function display device of fig 1a, one sub-pixel being in a light emitting state, and one sub-pixel being in a light sensing state, i.e. the display being in a so-called light sensing or scanning state.

Fig 2 is a diagram showing the normalized intensity of the absorption spectrum for a first example of a sub-pixel structure and the normalized photoconductivity spectrum for a second example of a sub-pixel structure display device under short circuit circumstances.

Fig 3 is a diagram showing the absorption spectrum for a first example of a sub-pixel structure and the emission spectrum for a second example of a sub-pixel structure display device under short circuit circumstances.

A display device in accordance with the invention is schematically shown in fig 1a and fig 1b. The shown display 5 comprises a single pixel, comprising a first and a second sub-pixel 5a, 5b. It shall however be noted that a display incorporating the present invention may comprise a plurality of pixels, each comprising two or more sub-pixels, as will be described below. The display is arranged to be driven in two temporally separated modes, namely a first emission mode, in which light is emitted from all sub-pixels (fig 1a), and a second sensing mode, in which the second sub-pixel is arranged to emit light of a certain wavelength, while the first sub-pixel is arranged to sense incident light of the same wavelength (fig 1b), as will be more closely described below.

The first sub-pixel 5a comprises a first active organic electroluminescent layer 1a, of for example an electroluminescent polymer material or a small molecule material, being sandwiched between a first front and back electrode 2a, 3a. The front electrode 2a functions as a so-called hole-injecting layer/anode, and the back electrode 3a functions as a so-called electron injecting layer/cathode. The material of said first electroluminescent layer is chosen so that a first wavelength $\lambda 1$ is emitted in the first emission state or mode, when a first emission state voltage V_{a1} is applied over said first electroluminescent layer 1a, by means of a first power source 6a, being connected to said electrodes 2a, 3a. Moreover, in this embodiment of the invention the second sub-pixel 5b comprises a second light emitting

material layer 1b, such as an active organic electroluminescent layer, as described above, also being sandwiched between two electrodes, 2b, 3b. The second sub-pixel is arranged to emit light having said second wavelength $\lambda 2$, when a second emission state voltage V_{bl} is applied over said first electroluminescent layer 1b, by means of a second power source 6b, being connected to said electrodes 2b, 3b. Consequently, in the light emitting mode of the display, as shown in fig 1a, a voltage V_{al} is applied over the first sub-pixel 5a, and a voltage V_{bl} is applied over the second sub-pixel 5b.

Moreover, since at least the first electroluminescent layer 1a is constituted by a electroluminescent polymer layer or a small molecule material layer, it is inherent that, when biased at a signal different than the driving signal V_{al}, namely a sensing voltage V_{as}, as will be described below, incident light on the electroluminescent layer 1a give rise to a photocurrent I_{ph} through the layer material, which may be detected.

Furthermore, the material of said first electroluminescent layer 1a of the first sub-pixel 5a is such that incident light of a second wavelength $\lambda 2$, being emitted by said second sub-pixel 5b induces a photocurrent I_{ph} in said material, when the sensing state voltage V_{as} is applied over said electroluminescent layer 1a. The photocurrent generated by the present invention may for example be measured, by measuring the voltage drop over a measuring circuit 7a, being connected between said first front and back electrodes 2a,3a. Moreover, light having said first wavelength $\lambda 1$ is arranged to have a lower energy content than light having said second wavelength $\lambda 2$, i.e. $\lambda 1 < \lambda 2$.

Furthermore, the display device 5 may or may not comprise a front substrate 4, having the functions of stabilizing the display device, and separating the active display parts from a potential user.

As is described above, at least the first sub-pixel 5a of the inventive display device has dual functions and may be driven in two modes or states by switching the display between light emitting operation, as shown in fig 1a and scanning/sensing operation, as shown in fig 1b. Said switching may be done automatically by using a pulsed driving scheme, or by a command from a potential user of the device. It is also possible to generate a display, that may only be driven in the scanning/sensing state as in fig 1b.

As described above, in a first light emitting state (Fig 1a), a second emission voltage V_{bl} is applied over the second electroluminescent layer 1b by means of a power source 6b, whereby light having a second wavelength $\lambda 2$, is emitted from said second organic electroluminescent layer 1b. Moreover, a first emission voltage V_{al} is applied over the organic electroluminescent layer 1a by means of a power source 6a, whereby light, having a

first wavelength $\lambda 1$, is emitted from said organic electroluminescent layer 1a. The first and second electrode 2a,3b described above exhibits different work functions. Thereby optimal charge injection into the polymer layer may be achieved during the emission state, since the work function is a measure of the energy required to remove an electron from the surface of the first and second electrode 2a,3a, respectively. The first electrode 2 (the hole-injecting layer) has a high work function (Φ_1), and this electrode is arranged to remove electrons from the valence states with high binding energy, and leaves positive holes behind in these states. The second electrode 3a (the electron injecting layer) has a low work function (Φ_2), and the electrons are loosely bound in the material. The second electrode 3a is arranged to inject negatively charged electrons in the conduction states of the material, where the electrons also have a low binding energy. Under forward driving (where the first electrode is positive and the second electrode is negative), the holes and electrons move towards each other, whereby the electrons fill up the holes and the increase in binding energy results in the release of a photon, i.e. light is emitted, having said first wavelength $\lambda 1$. When the device is driven in the light emission state, a certain voltage, referred to as the built-in voltage of the device, needs to be applied before any current will start to flow through the device. After this built-in voltage $V_{b\text{-}i}$ has been reached the size of the current through the display device will increase rapidly. The size of said built-in voltage is proportional to the difference between the work functions of the first and second electrodes.

In a second sensing state (Fig 1b), the second emission voltage V_{bl} is still applied over the second electroluminescent layer 1b of the second sub-pixel 5b by means of the power source 6b, whereby light having the second wavelength $\lambda 2$, is emitted from said second organic electroluminescent layer 1b. However, in this state a sensing driving voltage V_{as} is applied over the first organic electroluminescent layer 1a of the first sub-pixel 5b, said voltage being applied by the power source 6a or by means of a separate power source (not shown), and incident light on the first sub-pixel 5a, having the wavelength $\lambda 2$, give rise to the generation of a photocurrent I_{ph} in the first organic electroluminescent layer 1a. According to this invention, said sensing driving voltage V_{as} has a zero value (V_{as}=0V, short circuit configuration), i.e. a zero voltage is applied over the first organic layer 1a. By using short circuit configuration, the power consumption of the display may be minimized, and the influence of leakage currents may be eradicated. In the short circuit state, the two electrodes of the first sub-pixel, now having the same potential, are separated by the insulating organic electroluminescent layer 1a, for example being a polymer layer. However, in said layer there are always present small leakage paths, through which small amount of charge is allowed to

flow, provided there is a driving force. Due to the above-described difference in work function between the first and second electrode, electrons in the layer 1a experience a high binding energy of the first electrode 2a and a low binding energy of the second electrode 3a. Thereby, electrons will move from the second to the first electrode, and a small transient current I_{tr} (present during a short time only) will flow, until a balance state is reached. Initially, both electrodes where neutral, but due to said transient current, the first electrode becomes negatively charged and the second electrode becomes positively charged, resulting in a negative field over the organic layer 1a. As indicated above, zero applied voltage have advantages relating to the leakage current and the low power consumption necessary for the sensing state. At 0 V applied voltage, the electrodes 2a,3a are set at the same voltage, and therefore, the leakage current are forced to 0 since no external field is applied over the organic layer 1a. However, the above transient current gives rice to an negative internal electric field which is used to drive a photocurrent, generated as external light hits the device in the sensing state. In the above case, the size of the internal field is given by:

$$E_{\text{int}} = V_{b-i} / t_{layer}$$

where, E_{int} is the internal field, V_{b-i} is the above built-in voltage and t_{layer} is the thickness of the organic layer 1a. When illuminating the device, electrons being in an valance state is excited to a conduction state, and the negative internal electric field breaks the electron hole pair and draws the electron to the second electrode 3a (the cathode) and the hole to the first electrode 2a (the anode). Consequently, a small, measurable photo-current is generated. Furthermore, since the built-in voltage V_{b-i} is proportional to the difference between the two work functions of the first and second electrode, respectively, the internal electrical field is also proportional to the work function difference, i.e. the larger the difference between the two work functions, the larger the internal electric field at 0 applied voltage. Moreover, a large work function difference is also required for an optimal emissive state, and thereby a device is achieved, which may be optimized for emission, however still having an effective, and power efficient sensing state.

For present-day electrodes, the work function difference may be made large, resulting in high values of the built-in voltage V_{b-i} between 1.4 and 3.1 Volts. Moreover, it has been found that the optimal thickness of the organic layer 1a is in the interval between 60-90 nm and preferably about 70 nm, in order to achieve a high efficiency emission state.

Consequently, this invention provides for a interactive/scanning display device, by spectrally subdividing the sensor stage and the emission stage of the display. A reflecting object placed on or near the display surface is illuminated by (high energy) emitting sub-pixels, while the reflected light is sensed under short circuit conditions by (low energy) sensing sub-pixels.

Specifically, the present invention makes it possible to include such scanning and/or interactive abilities in an organic color display, such as an RGB display. In such a display, each pixel comprises three sub-pixels each being arranged to emit light of mutually different wavelengths, namely red light λ1, green light λ2, and blue light λ3. A color display requires the above three colors in order to map a large fraction of the so-called color triangle, and thereby be able to represent a large fraction of the colors present in the visible spectrum, on per se known manner. However, in a organic electroluminescent device, using for example a polymer electroluminescent material, the energy differences between the different colors naturally more or less corresponds with the so called Stokes shift (~100-150 nm) of the polymer material. (The Stokes shift is equal to the energy difference between the absorption and the emission of the material). Consequently, the emission bands of the high energy pixels essentially corresponds to the absorption bands of the low energy pixels of the color display, and thereby a scanning display may be realized by starting from a standard electroluminescent display device.

A sensing state in such a device may be realized in several different ways:

1) using the blue sub-pixel for emitting light, and the red and/or green sub-pixel for sensing reflected light.

2) using the green sub-pixel for emitting light, and the red sub-pixel for sensing reflected light.

3) using the blue and green sub-pixels for emitting light, and the red sub-pixel for sensing reflected light.

It shall be noted that the illumination is performed by sub-pixels emitting higher-energy photons, such as blue and/or green sub-pixels, and the sensing is performed by sub-pixels emitting lower-energy photons such as green and/or red sub-pixels.

Furthermore, as indicated above, the organic electroluminescent materials, such as the active polymers in a polymer light emitting device (poly-LED) have a very specific spectral absorption and emission behavior. The light absorption feature is situated at

distinctly higher energies than the emission feature (typically 0.6 eV higher). For example, in PPV (polyphenylene vinylene) polymers, the spectral dependence of the photoconductivity coincides up to a great extent with the absorption behavior, as is visible from fig 2. Thereby, the moment that the energy of an incoming photon is sufficient to create an exciton (bound electron-hole pair), charge carriers are generated, due to exciton break-up in the polymer layer.

Furthermore, as mentioned above, the wavelength difference between the absorption and the emission feature is typically 100-150 nm, as is visible from fig 3. Fig 3 discloses the absorption and emission spectrum of a yellow PPV polymer, given as an example only. In fig 3, the absorption was measured for a 100 nm polymer layer on glass while the emission spectrum was measured for a 75 nm polymer layer in a ITO/PEDOT-PSS/Yellow PPV/BaAl device. The above wavelength difference is commonly assigned to the Stokes shift and is believed to be due to structural relaxation effects and a migration of excitons toward lower energy states during their lifetime (approximately 1 ns). This invention is based on the realization that the overlap between the emission and the absorption spectrum of the same polymer is too small to give an appreciable photo-response, and moreover, the above Stokes shift indicates the need of a spectral sub-division of the sensing and the emitting state in a scanning device or the like.

In accordance with the above stated, this invention further makes it possible to generate a full color display (such as an RGB-display) having an incorporated scanning ability. Furthermore, it may be shown that the inventive short circuit configuration has a short response time. The response time is an especially important property for interactive applications. The reason why the response time is of importance is because one would like to incorporate the sensor action in the multiplexed driving operation of the device. Simulations give that the response time for a display utilizing short circuit configuration is in the order of 10 μs, being short enough to acquire a desired amplification of the signal.

Furthermore, the display device according to the invention is arranged to be driven by a pulsed driving signal. As is described below, a display in accordance with the invention may in practice be used in two different ways, namely as a scanning display being arranged to display a picture for a spectator, the display continuing to display said picture in the sensing state, or as a pure scanning display, in which the emission is used to illuminate an object only, and are not intended to hit the eye of a potential spectator.

In the first case, a pulsed driving scheme is suitable in order to avoid the incorporation of the sensing state to be noticed by a human eye. In this case, the duration of the pulses is of the order of 10 ms (within the interval 0-20 ms).

In the second case, a pulsed driving scheme is beneficial for amplification purposes, the duration of the pulses being of the order of 10 ms (within the interval 0-20 ms) at sufficient amplification of the signal. Due to the short response time described above, it is possible to measure short, high signals, since the short pulses in this case enables the use of high-intensity light, without excessive heating of the display, which may improve the sensing signal by at least a factor 2. Moreover, for a constant value of the total dissipated energy, the voltage over (or the current through) the electroluminescent layer, may be increased when decreasing the pulse time, thereby enabling an increase of the photocurrent signal. Such a pulsed driving scheme is highly suitable for polymer LEDs, especially in passive matrix configuration. Moreover, the pulsed driving scheme increases the light intensity. As an example, for a multiplexed driving scheme with 15.6 ms driving pulses (64 cathodes), the light intensity in the pulse increases by a factor 64, since the power is proportional to the light intensity. Moreover, for an RGB display in a passive matrix configuration, the pulses are expected to be a factor tree shorter (3*64 cathodes), leading to a further increase of the photo response by a factor three.

The display device according to the invention may for example be arranged as a scanning device, for scanning a surface, such as bar-codes, as described below, or fingerprints. In the last case, a high resolution display is required. Here, the emitting sub-pixels are arranged to illuminate a reflective object, placed on an outer surface of the display, or in proximity of said display, and the light is reflected from that object and sensed by the sensing sub-pixels, as is described above. This invention provides for the performance of line scans, by illuminating with one column, comprising several pixels, and measuring/sensing by another column, such as a neighboring column. By shifting the emitting column, for example each blue-emitting column from left to right, while sensing by another, neighboring column, for example each green-emitting column, it is possible to scan over any surface. Especially, such a device may be used for scanning bar codes or the like, when the device is in a scanning/sensing mode as indicated by fig 1b. Thereafter, information being represented by said bar code, may be displayed on the display surface, when the device is in a light emitting mode, as in fig 1a. As described above, the illumination column may be a column emitting blue or green light, while the sensing column may be a column sensing green or red light.

A second application of the present invention is as an interactive display device. Here, a separate light reflection device, such as a mirror pen, is arranged to be positioned in proximity of the surface of said display, said display being a matrix display, comprising a plurality of pixels, each comprising sub-pixels as described above. When said reflection device is placed in proximity with the display surface, it reflects light, emitted from said display, whereby the reflected light may be detected by the sensing sub-pixels of the display. By using a reflection device having a reflective surface, that is smaller than the display area, the reflection device may be used as a pointer, as an alternative "mouse-device" in order to generate an interactive display device.

It shall be noted that a display utilizing the invention preferably includes a plurality of pixels, each having two or more sub-pixels. In this case several surrounding pixels or sub-pixels may be used to detect light reflected from an object and emitted from a centrally positioned pixel/sub-pixel. By using measurement information from several surrounding pixels/sub-pixels it is also possible to acquire information regarding the shape of an object, acting as a reflection surface. Thereby, the spatial resolution of the scanning device may be improved, compared with the use of only one sensing pixel/sub-pixel.
Moreover, a display device in accordance with the invention may also be used for example for optical data-transfer applications. In this case two RGB polymer LED devices, essentially as described above, is used. High energy pixels of a first device is arranged to transmit a signal containing information, e.g. digital information, while the lower energy pixels of a second device is arranged to receive and sense the signal and translate it into direct information. In summary, this invention provides for a interactive/scanning display device, by spectrally subdividing the sensor stage and the emission stage of the display. The display is sensitive to light emitted by the display itself. Moreover, the emission and sensing of light occurs essentially simultaneously during a sensing state. The device is switchable between a light emitting state and a scanning state. A reflecting object placed on or near the display surface is illuminated by (high energy) emitting sub-pixels, while the reflected light is sensed under short circuit conditions by (low energy) sensing sub-pixels. The reflecting object may be a small mirror, for example placed on the tip of a mirror pen, but may also be any other object provided that a certain amount of light (such as more than about 1% for MUX64 driving) of the incident light is reflected by the object and thereafter falls onto the active layer of a sensing sub-pixel. For the case of a mirror pen, an optimization due to geometry (since sensing and emitting are spatially separated) may be achieved. Furthermore, the display device has a low power consumption in the sensing state. Moreover, the leakage currents of

the organic device are equal to zero. Therefore, their typical unstable behavior does not interfere with the sensing properties of the device. It shall also be noted that, due to the size of the photo-response, a pulsed driving scheme is preferred or necessary for a proper function of such a display. By decreasing the pulse-time, it may be possible to further improve the sensing amplitude.

It shall be noted that many variations and modifications of this invention are possible for the man skilled in the art. For example it shall be noted that the method and device according to the invention may be applied to a single segment device (lighting device), a segmented device or a matrix display. The invention may also be used in passive as well as active matrix configurations. It shall also be noted that zero voltage and zero current in this application is meant to be interpreted as essentially zero values. It shall also be noted that essentially any technology may be used for generating the light to be reflected, as long as the dual-function (light emitting/sensing) sub-pixels is according to the invention, as described above. For most practical applications, however, it is not desired to use two technologies in the same display, and consequently, a preferred embodiment of this invention have sub-pixel all comprising an organic light emitting layer as described above, said sub-pixels being arranged to emit light of different wavelengths.

Moreover, it shall be noted that two different scanning modes may be achieved by the present invention. In the first one, the scanning display is arranged to display a picture, and the display continues to display said picture in the sensing state. This is for example the case in the mirror pen example above. This application requires a pulsed driving mode in order to be able to use sensing pixels simultaneously with emission pixels. The second scanning mode is a pure scanning mode, in which the emission is used to illuminate an object, wherein the sensing pixels are arranged to be operated simultaneously with the emission pixels.

CLAIMS:

1. A display device (5), comprising at least a first and a second sub-pixel (5a, 5b), said first sub-pixel (5a) being arranged to emit light of a first wavelength ($\lambda 1$) and said second sub-pixel (5b) being arranged to emit light at a second wavelength ($\lambda 2$), said first sub-pixel (5a) comprising a first light emitting organic electroluminescent layer (1a), such as a polymer layer or a small compound molecule layer, being sandwiched between a first front electrode (2a) and a first back electrode (3a), wherein said first electrodes (2a,3a) in a first state are arranged to apply an emission driving signal (V_{al}) over said first electroluminescent layer (1a), for generating an emission state in which light of said first wavelength ($\lambda 1$) is emitted, and in a second state are arranged to apply a sensing driving signal (V_{as}) over said first electroluminescent layer (1a), in which light of said second wavelength ($\lambda 2$), incident on said first sub-pixel (5a) may be detected.

2. A display device as in claim 1, wherein said first electrodes (2a, 3a) are held at essentially equal potential, i.e. said sensing driving signal being a voltage having a value of essentially 0 Volts.

3. A display device as in claim 1 or 2, wherein light emitted from said second sub-pixel (5b), having said second wavelength ($\lambda 2$), is arranged to be reflected and detected by said first sub-pixel (5a) during said light sensing state.

4. A display device as in claim 1, 2 or 3, wherein light ($\lambda 1$) emitted from said first sub-pixel (5a) has a lower energy content than light ($\lambda 2$) emitted from said second sub-pixel (5b).

5. A display device as in any one of the preceding claims, comprising a plurality of pixels, each comprising a first and second sub-pixel (5a, 5b), whereby light emitted from a chosen second sub-pixel is arranged to be reflected by an external reflection device, being arranged in proximity of said device, and sensed by at least one first sub-pixel (5a) within a

neighboring area.

6. A display device as in any one of the preceding claims, wherein said display comprises a plurality of pixels, and whereby light emitted from a second sub-pixel is arranged to be detected by a plurality of neighboring pixels, each having a corresponding first sub-pixel.

7. A device according to claim 1, wherein said first front and back electrodes (2a, 3a) each exhibits a work function (Φ_1,Φ_2) and the difference between said work functions in larger than 1 eV, preferably within the interval 2-3.5 eV.

8. A device according to claim 1, wherein at least one of said emission driving signal during the first emission state and said sensing driving signal during the second sensing state, is constituted by a pulsed driving signal, the duration of the pulses being within the interval 0-20 ms.

9. A device according to claim 8, wherein, in said second state, said sensing driving signal is a pulsed driving signal comprising high intensity pulses, in order to amplify the sensing driving signal.

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ABSTRACT:

This invention relates to a display device (5), comprising first and a second sub-pixel (5a, 5b), said first sub-pixel (5a) emitting light of a first wavelength ($\lambda 1$) and said second sub-pixel (5b) emitting light at a second wavelength ($\lambda 2$), said first sub-pixel (5a) comprising a first organic electroluminescent layer (1a), such as a polymer or a small compound molecule layer, being sandwiched between a first front and back electrode (2a, 3a), in a first state applying an emission driving signal (V_{al}) over said first layer (1a), for generating an emission state in which light of said first wavelength ($\lambda 1$) is emitted, and in a second state applying a sensing driving signal (V_{as}) over said first layer (1a), whereby light of said second wavelength ($\lambda 2$), incident on said first sub-pixel (5a) may be detected. Preferably said first electrodes (2a, 3a) are held at essentially equal potential.

Elected for publication: fig 1a and 1b

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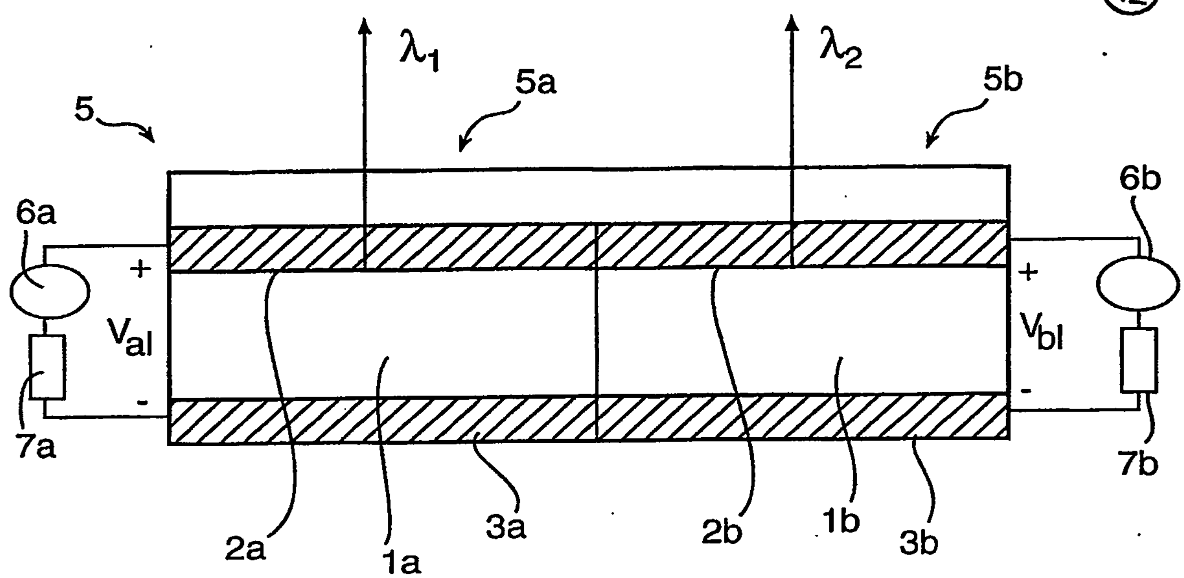

FIG.1a

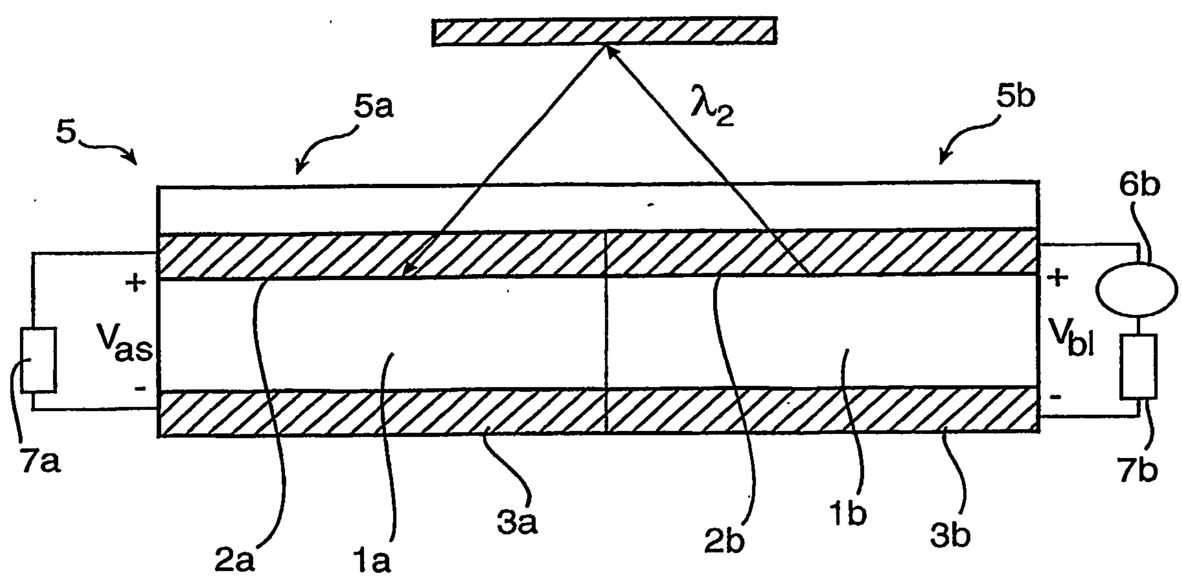

FIG.1b

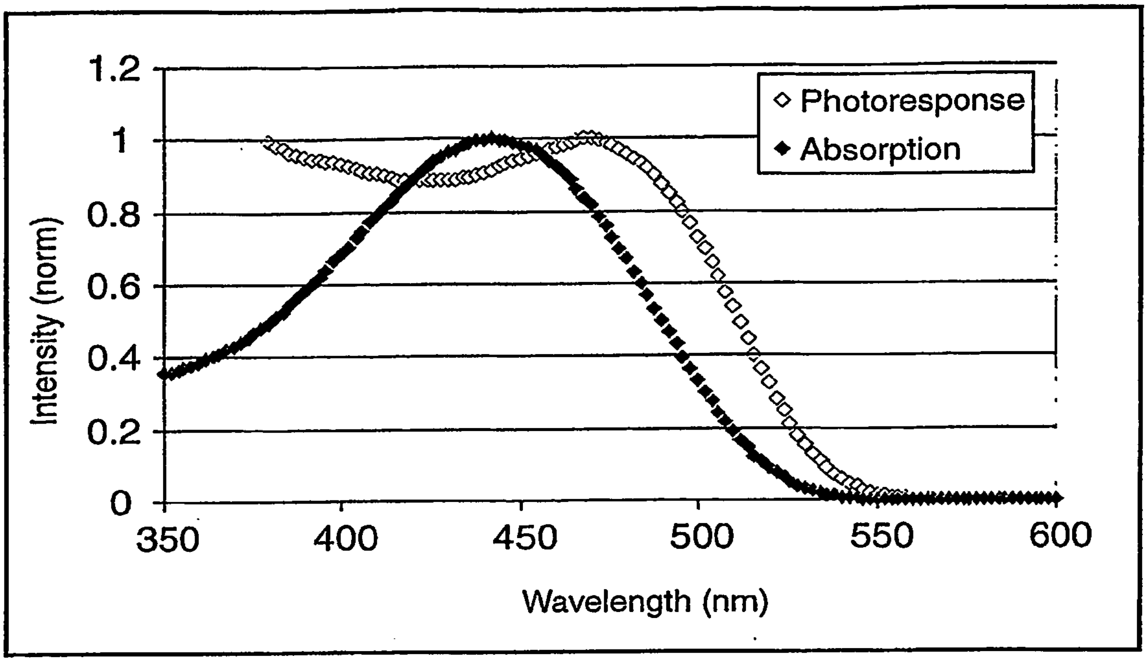
1.2
1
0.8
0.6
0.4
0.2
0
350
400
450
500
550
600
Intensity (norm)
Wavelength (nm)
Photoresponse
Absorption

FIG.2

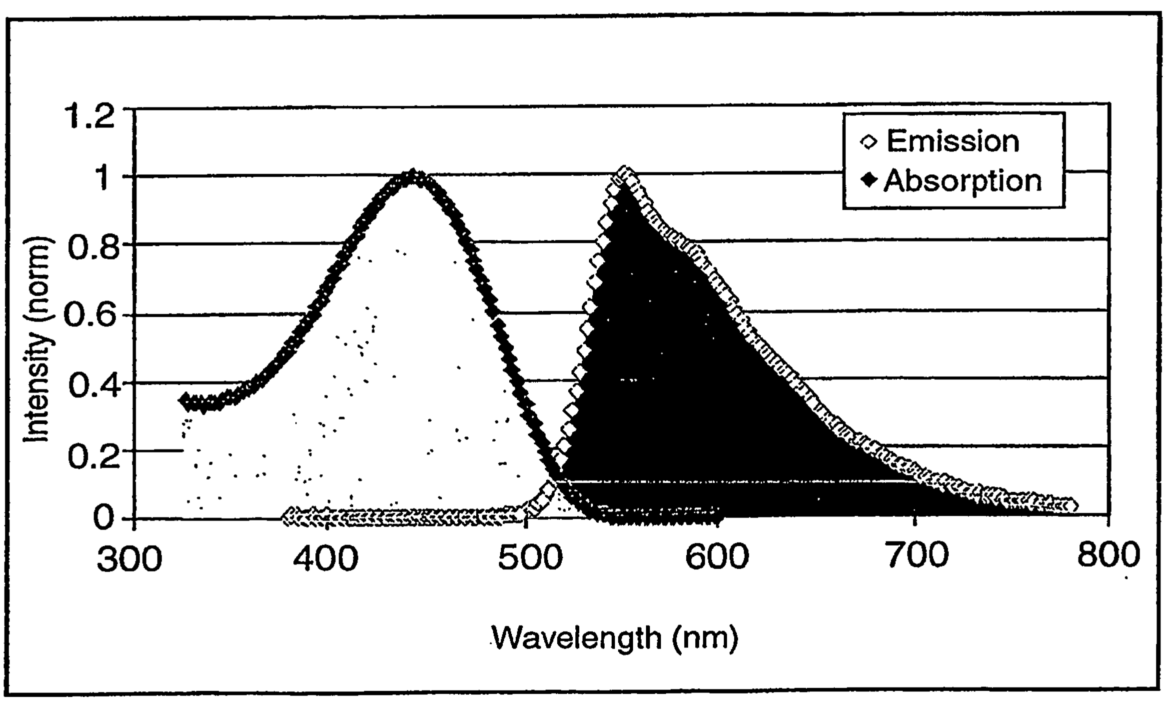
1.2
1
0.8
0.6
0.4
0.2
0
300
400
500
600
700
800
Intensity (norm)
Wavelength (nm)
Emission
Absorption

FIG.3